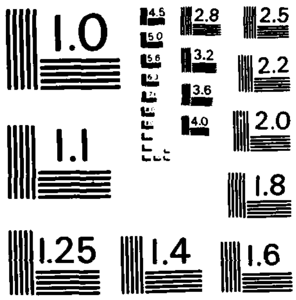
AD-A132 411 OPTICAL PROPERTIES OF THE MARINE AEROSOL AS PREDICTED BY A BASIC VERSION OF THE NAVY AEROSOL MODEL(U) NAVAL RESEARCH LAB WASHINGTON DC S G GATHMAN 02 SEP 83 1/1

UNCLASSIFIED NRL-MR-5157 F/G 20/6 NL

END
DATE
FILMED
9 83
DTIC




MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

②

NRL Memorandum Report 5157



# Optical Properties of the Marine Aerosol as Predicted by a BASIC Version of the Navy Aerosol Model

S. G. GATHMAN

*Atmospheric Physics Group*
*Environmental Sciences Division*

September 2, 1983

NAVAL RESEARCH LABORATORY
Washington, D.C.

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

| REPORT DOCUMENTATION PAGE | | READ INSTRUCTIONS BEFORE COMPLETING FORM |
|---|---|---|
| 1. REPORT NUMBER<br>NRL Memorandum Report 5157 | 2. GOVT ACCESSION NO.<br>AD-A132411 | 3. RECIPIENT'S CATALOG NUMBER |
| 4. TITLE (and Subtitle)<br>OPTICAL PROPERTIES OF THE MARINE AEROSOL AS PREDICTED BY A BASIC VERSION OF THE NAVY AEROSOL MODEL | | 5. TYPE OF REPORT & PERIOD COVERED<br>Interim report on a continuing NRL problem.<br>6. PERFORMING ORG. REPORT NUMBER |
| 7. AUTHOR(s)<br>S.G. Gathman | | 8. CONTRACT OR GRANT NUMBER(s) |
| 9. PERFORMING ORGANIZATION NAME AND ADDRESS<br>Naval Research Laboratory<br>Washington, DC 20375 | | 10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS<br>62759N; SF59551697;<br>43-1108-0-3 |
| 11. CONTROLLING OFFICE NAME AND ADDRESS<br>Naval Ocean Systems Center<br>San Diego, CA 92153 | | 12. REPORT DATE<br>September 2, 1983<br>13. NUMBER OF PAGES<br>34 |
| 14. MONITORING AGENCY NAME & ADDRESS(if different from Controlling Office) | | 15. SECURITY CLASS. (of this report)<br>UNCLASSIFIED<br>15a. DECLASSIFICATION/DOWNGRADING SCHEDULE |

16. DISTRIBUTION STATEMENT (of this Report)

Approved for public release; distribution unlimited.

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Extinction
Absorption
Size distribution
Marine aerosol
Relative humidity
Wind speed
Radon

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

A model is presented which predicts optical and infrared extinction and absorption from marine aerosol for wavelengths of 0.2 to 40 micrometers. The model utilizes standard meteorological measurements as inputs but has default values built into it so that input values are not absolutely necessary but when they are available they will

(Continues)

DD FORM 1 JAN 73 1473 EDITION OF 1 NOV 65 IS OBSOLETE
S/N 0102-014-6601

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

20. ABSTRACT (Continued)

increase the accuracy of the predictions. The model is based on aerosol size distribution measurement data taken by several investigators from platforms close to the sea surface. The optical predictions of the model are derived from precalculated terms stored in the program which were originally obtained from lengthy Mie calculations on special aerosol size distributions.

CONTENTS

# Optical Properties of the Marine Aerosol as Predicted by a BASIC Version of the Navy Aerosol Model

## INTRODUCTION

The quest for an atmospheric model which accurately describes the atmosphere's optical properties in terms of its meteorological properties has been a goal of the Navy's EOMET program from its inception. Such a model would describe the optical properties of the atmosphere from an input of easily obtained meteorological data. There are several atmospheric "windows" in the molecular absorption of electromagnetic energy in which transmission and communication at various visible and infrared frequencies can take place. In these windows the natural atmospheric aerosol plays an important part in degrading the transmission of radiation from point A to point B both by scattering and by absorption of the energy. Of particular interest to the Navy is the role natural marine aerosols play within the marine boundary layer in causing extinction at these wavelengths. IR extinction over the oceans is known to be a function of various meteorological parameters such as visibility, absolute humidity, relative humidity, and wind. This report is a shortened version of the more detailed report which is to appear in the proceedings of the workshop on hygroscopic aerosols in the planetary boundary layer in a book edited by A. Deepak and L. H. Ruhnke (1982) and is designed to get the essence of the model into users' hands as quickly as possible. It also includes a listing of the BASIC version of the model which is designed to work on the Tektronix 4052 desktop computer.

## MODEL DEVELOPMENT

The first part of the problem is to relate aerosol size distributions to the meteorological parameters. This is done by choosing a mathematical model to represent the number size distribution and then relating the various parameters used in the description of the model to the associated meteorological parameters.

The second part of the problem is to calculate the optical properties of the modeled aerosol. This is accomplished by the application of Mie theory on the functional form of the aerosol number density size distribution.

In the development of this model four of the most obvious meteorological parameters will be used to search for correlations with observed aerosol size distributions. The first is relative humidity which affects the size of hygroscopic aerosol particles by causing them to grow or to shrink so as to be in equilibrium size with their environment. The second meteorological parameter is the wind speed as this is the driving force which produces white water patches on the ocean and transports the resulting salt droplets throughout the boundary layer. The third is the visibility corrected for molecular extinction which is often available in meteorological records and can be used to upgrade the IR predictions of the model. The model incorporates this input by adjusting the entire aerosol size distribution up or down so that the model predicts precisely the input visibility value at a wavelength of 0.55 micrometers. The fourth is an input number which is an indicator of the airmass

Manuscript approved June 10, 1983.

quality (i.e., if the airmass is of continental origin or marine origin or in the grey area inbetween. Several methods are presented below which can be used to provide this information.

The relationship between the size distribution function and the ambient relative humidity has been investigated by a number of investigators and has been satisfactorily applied to the theory; see Fitzgerald (1978). A functional relationship which relates relative humidity effects to the observed number density size distribution can be accomplished in the subsaturated regime by the following scheme.

If

$$dN/dr = A*\exp(-C*(\ln(r/r0))^2) \qquad (1)$$

represents the lognormal size distribution at some standard relative humidity then

$$dN/dr = A*\exp(-C*(\ln(r/(f*r0)))^2)/f \qquad (2)$$

scales the size distribution for the same set of particles to other ambient relative humidities. Here "f" is a function of the relative humidity and is the ratio of the particle radius, r, at the ambient relative humidity to the size it would have at 80% relative humidity.

The process of incorporating the wind measurements into a mathematical representation of the aerosol size distribution on the other hand is not so neatly accomplished. An empirical relationship must be found which will relate some meteorological measure of the wind to the aerosol within the marine boundary layer. A large data base is needed in order to determine empirically the mean characteristics of these parameters and to correlate the dependence of these parameters on meteorological conditions as has been postulated.

Table I is a list of the aerosol size spectrum data that was considered in this report. This data is based mainly on tower data from an island off the California coast and on shipboard data from the north Atlantic Ocean.

Plotted altogether the data of Table I shows a broad band of values for each aerosol size bin. These values contain all of the variations in the size distribution from known causes such as different ambient relative humidity and wind speeds. It is the objective of any model to predict these variations in the size distribution from meteorological inputs.

An initial series of tests on the field data was performed on the observed size distribution data which were made by several of the multichannel size spectrometers, (P.M.S. aerosol spectrometers). The individual size distributions were smoothed with cubic spline smoothing techniques. The maxima of the individual components of the total aerosol are manifested as inflections in the total aerosol size distribution curve. Thus by observing the behavior of the derivative of the cubic spline approximation these inflection points are more easily detected. It is realized that several authors; Pinnick and Auvermann, (1979) and Allan and Ashdown, (1982) contend that there is a serious double-valuedness in the idealized PMC calibration curve which could be a major source of these inflections. Although at the present time, this is a point of controversy between investigators, these effects are largely nullified in the field calibration procedure of these instruments. It is felt that because these instruments can be adjusted to give Jungian-like size distributions under no-white-water conditions, that the data during white-water conditions which indicated peaks superimposed on the Jungian line in Log-log space can be trusted to some degree to describe the gross characteristics of the aerosol populations produced by the white water. Approximate locations of significant perturbations in the smoothed aerosol data were detected and are assumed to be near the maxima of certain subspecies of aerosol within the total aerosol population. The statistical results of this analysis show that three distinct populations are observable within the aerosol size distributions. This result provides at least a plausible basis on which to postulate a three-component aerosol model for the marine environment. Any natural size distribution can then be represented by a linear combination of three lognormal distributions, each of the functions is individually characterized by three independent parameters giving a total of nine parameters describing the individual size distribution. This is illustrated in figure 1 which shows in an idealized fashion this three component model. One can obtain these parameters by using data fitting techniques on a single size distribution measurement assuming that the measurement contains at least nine different sizes. The various parameters describing these functions are then related to the meteorological measurements at the time the spectra were obtained. The parameters of the lognormal representation have visible and physical significance that is observable from plotted size distributions. The amplitude parameter, A, is the maximum value the function obtains. The mode radius, $r_o$, describes where this maximum value occurs. Finally the width parameter, C, describes how narrow or broad the distribution is narrow and if C is a small number then the distribution appears very broad. The parameter C is related to the standard deviation of the size distribution, $\sigma$, as:

$$C \sim 1/(2\ \sigma^2) \tag{3}$$

After looking at hundreds of aerosol spectra it was discovered that the width parameter of the lognormal distribution, C,was not a noticeable function of wind speed. In fact the widths of all three lognormal components could easily be kept at a value of +1 with no loss in information. The mode radius parameter of the lognormal functions (measured at 80% relative humidity) could also be represented to the best of our present knowledge by wind-independent values that are determined from the statistical analysis described above. This leaves the amplitudes of the three wind-dependent parameters to describe changes in the size distribution through correlation with some function of the wind representation. Thus the marine aerosol size model is postulated as a combination of three lognormal distributions of fixed shape but with variable position and amplitude.

The three distributions represent three classes of aerosol each of which has a separate existence from the others. The smallest size class is that represented at relative humidity of 80% by a lognormal with a small mode radius of $r_o$ = 0.03 microns. This is the background aerosol and is related to the airmass characteristics and does not seem to respond to local wind parameters. Being airmass dependent, however, it can be related to a measurable parameter such as the atmospheric radon content or the elapsed time taken by the observed airmass to traverse the sea from the continent to the current location. Hoppel (1979, 1981) found that during this transit it is being modified from a "continental" type of air mass with very many small nuclei to a "marine" type of air mass which has several orders of magnitude less nuclei in the smaller size ranges.

The second class of aerosol in this model is that represented by a lognormal distribution which has an $r_o$ = .24 microns at the standard relative humidity of 80%. This class is populated by marine aerosols which have been produced by earlier high wind conditions but which once introduced into the atmosphere exhibit a relatively long residence time and are still well mixed throughout the marine boundary layer. It doesn't make much sense to say that the concentrations of these aerosols are related to the current wind speed. They are in effect related to the history of the wind. In our simplification of the problem we will represent the amplitude of this component to be correlated with the previous twenty-four hour average of wind as an attempt to tie this class of aerosol with an historical relationship of the wind.

The third and last class of aerosol is that of the largest nuclei originating from the sea surface which can be important in the propagation of infrared radiation near the sea surface. These aerosols are represented in this model by a lognormal distribution which has an $r_o$ = 2 microns and an amplitude which is definitely related to the current wind speed and the current white water phenomenon.

DATA FITTING

Taking into account the time dependence of the different aerosol species it then becomes a problem in determining the wind relationships between the remaining three lognormal parameters and the historical wind, represented by a long-term air mass movement, a 24-hour average of the measured wind and of the current wind speed represented by the one-hour average wind at the time of the aerosol measurement. For this analysis the best available sets of aerosol data which included the appropriate concurrent meteorological parameters were used. For this analysis data from a multichannel aerosol spectrometer and adequate wind speed information were required. Only data in which pure oceanic air was sampled for fear that the wind dependence of the larger two aerosol species might be swamped out by polluted air samples.

Two sets of data with wide meteorological variance and different geographical settings were used. Specifically the data used to determine the wind dependence of the three aerosol size parameters was that of the FITZROY cruise and that of the May 79 San Nicolas Island hi-mode data set.

Each of the hourly aerosol size distribution measurements was adjusted for a relative humidity of 80% and fitted with the model and the values of the three amplitudes determined. Associated with each of the many data sets were the current wind speed measurement and the average wind speed of the previous 24 hours. Table 2 shows the correlation matrix between the variables of interest and is used to determine the significance of the wind dependence of the three lognormal amplitudes. The matrix shown indicates that there is no significance to the variation of the first amplitude with respect to either of the wind representations. As expected it is not dependent on local meteorology but only a function of the air mass characteristic which is a large-scale phenomenon. However it is significant that the second amplitude shows a strong correlation with respect to both wind-speed representations. It also shows an even higher correlation with the average wind-speed parameter than with the current wind-speed data. The A3 amplitude shows a strong correlation with wind speeds but this parameter shows the strongest correlation with respect to the instantaneous wind speed. Regression techniques were employed to determine from the field data sets what the respective relationship between the A2 and A3 amplitude parameters and the 24 hour average wind and the instantaneous wind measurements were. Because there is no basis for a more complicated functional relationship, a linear regression was used. The description of the A1 amplitude parameter was shown not to be related to wind speed but from many experiments Hoppel (1982) has suggested that this component is a function of the air mass characteristics and changes slowly as a continental air mass moves out to sea. The amplitude is high for coastal areas and decreases toward the open ocean. The value of this parameter can be tagged to a meteorological measurement such as atmospheric radon content or simply a subjective determination of the type of air mass determined from large scale weather maps.

The Navy model can now be described completely as:

$$
\begin{aligned}
dn/dr &= k \cdot A1 \cdot \exp(-1 \cdot (\ln(r/.03))^2) \\
&+ k \cdot A2 \cdot \exp(-1 \cdot (\ln(r/.24))^2) \\
&+ k \cdot A3 \cdot \exp(-1 \cdot (\ln(r/2.))^2)
\end{aligned} \tag{4}
$$

where k = 1 if no visibility measurement is available but can be adjusted to fit the measured visibility as discussed later. Here we define the first amplitude as:

$$A1 = 2000 \cdot (P)^2 \tag{5}$$

where P is an integer between 1 and 10. It can be based on empirical judgment or simply be related to the measurement of atmospheric radon content, Rn, (expressed in pico curies per cubic meter), Larson and Bressan (1980):

$$P = \mathrm{INT}(Rn/4) + 1 \tag{6}$$

It can thus also be related to t, the elapsed time for the current air mass to reach the point of observation.

$$P = INT(9 \cdot \exp(-t(days)/4) + 1 \quad (7)$$

The second and third amplitudes are expressed as:

$$A2 = 0.5 \text{ MAX } 5.866 \cdot (\omega o - 2.2) \quad (8)$$

$$A3 = .000014 \text{ MAX } .01527 \cdot (\omega' - 2.2) \quad (9)$$

where $\omega o$ is the 24 hour average wind, $\omega'$ is the current wind speed all expressed in meters per second. The MAX function expresses the fact that the parameter is the largest of either of the two components. The units of A1, A2 and A3 are the number of particles per cubic centimeter per micrometer.

DETERMINING THE OPTICAL PROPERTIES

The second part of the problem is to express the atmospheric optical properties in terms of the functional form of the aerosol number size distribution. This is accomplished by the application of Mie theory to a known distribution of assumed spherical droplets suspended in the atmosphere. In order to do this calculation it is necessary to know the complex index of refraction of the droplets. It is known that the chemical composition of the droplets changes as a function of relative humidity. A perfectly dry particle has a complex index of refraction of the nucleus material. On the other hand in a very high relative humidity environment, the hygroscopic particle will have changed size, taking on a considerable amount of water with the nucleus dissolved into the water. Hanel (1971) solves the problem by making a straight volume dependence between the complex index of refraction for the nucleus material and the complex index of refraction for water. This method is followed in the model's calculations. The wavelength dependence of the complex index of refraction for water used here is published in Hale & Query (1973) and that for the nucleus which we assume to be water soluble is that listed by Voltz (1972).

The Mie efficiency coefficients, Qext and Qabs are calculated by the method of Dave (1968). Using these coefficients and the functional form of the aerosol size distribution, the volume extinction coefficient and the volume absorption coefficient can be calculated for each wave length of interest and for each relative humidity.

$$\beta_{ext} \sim \int Q_{ext} \cdot n(r) \cdot r^2 \, dr \quad (10)$$

$$\beta_{abs} \sim \int Q_{abs} \cdot n(r) \cdot r^2 \, dr \quad (11)$$

For this specific case the integration can be indicated as:

$$\beta = \frac{\pi}{1000\ f} \int Q \sum_{J=1}^{3} A_J e^{-\ln^2 \frac{r}{f\, r_{oj}}} r^2 \, dr \quad (12)$$

One feature of this formulation is that now the time-consuming integration can be precalculated for various relative humidities as:

$$\beta = \frac{\pi}{1000\ f} \sum_{J=1}^{3} A_J \cdot \int Q\ e^{-\ln^2 \frac{r}{f\ r_{oj}}}\ r^2 dr \tag{13}$$

The final form of the model now utilizes these precalculated integrals and stores a set of these values for various sets of relative humidities and wave lengths. In the practical application of this model, the calculation is reduced to finding the integral for a specific relative humidity and wavelength by interpolation between the stored values in the tabl

IMPLEMENTATION OF THE MODEL

The BASIC form of the model is designed to operate on a [illegible]ll desktop computer and has graphing capabilities to present either the [illegible]-log plot of the aerosol size distribution or of the variation of the vol[illegible] [illegible]cinction coefficient or the volume absorption coefficient as a functio[illegible] [illegible] wavelength.

The aerosol model has a set of default conditions which if specific measurement inputs are not known, the computer code will supply best estimate values for the specific geographic zone in which the calculation is to be used. Visible range adjusted for molecular extinction is an input to this model. When this input parameter is available the model calculates what the visible range (at 0.55 microns) would be from the other available inputs and then adjusts all of the three lognormal amplitudes so that the predicted visual range at .55 microns is the same as that provided as input. At sea accurate visibility data is difficult to obtain; therefore, unless good visibility measurements are available, it is suggested that the default visibility condition be used.

The model has certain limitations which must be kept in mind. The data sets on which it is based were surface data taken within the lowest 30 meters of the sea surface. The altitude range of the model as defined is not large. It is designed to work at the sea surface on horizontal path calculations. It is expected that the smallest and the medium size components of the aerosol will be well mixed and uniform throughout the marine boundary layer. On the other hand, the largest size component undoubtedly will have some form of height factor which is effective throughout the marine boundary layer. Future improvements of the model will have some form of scale height term multiplying the A3 amplitude which will allow slant path calculations for times of high inversion heights. In the majority of cases with low marine inversions, however, a constant factor is adequate.

A second limitation in the model is that it is assumed that all of the components are composed of soluble aerosol such as is found over the ocean. It is expected that there will be times when the composition of the smallest size component will be of a non-soluble chemical composition of continental origin in which the complex index of refraction of the actual aerosol will be very different from that assumed in the model. Care must therefore be exercised in the application of the model when unusual cases such as the presence of Sahara dust or specific industrial pollutants are suspected.

A third limitation of the model is produced by the lack of adequate large size aerosol data. From the data used in the assembly of this model, and within the wind speeds encountered in these measurements, a constant mode radius of the largest size component was adequate. It is possible however that at very high wind speeds the mode radius at 80% relative humidity may shift to larger sizes.

## OPERATION OF THE PROGRAM

The program in Appendix I is based on the Navy Aerosol Model described above. It relates the optical quantities of aerosol extinction and absorption throughout the wavelengths of .2 micrometers to 40 micrometers to certain measurable meteorological parameters such as relative humidity, wind speed, wind history, and a subjective determination of air mass quality. This later subjective parameter can be more precisely quantified if air mass trajectories are available or if a method of determining the atmospheric radon content is available.

The program has been designed to be used in the interactive mode whereby the computer asks questions about the meteorology of the environment and then when its questions have been fully answered, it presents a menu whereby several options for output presentations are available.

The general program flow is illustrated by the flow chart shown in Figure 2. The first major step is the program assignment of stored data values to program data arrays. The remainder of the program is determined by the user's desires as determined by the menu select part of the program. The menu select routine (see Figure 3) is entered after an initial set of input parameters has been obtained from the user input interview subroutine. At this time any of the option is available to display, plot, or store information predicted by the model and based on the previous input parameters. One of the options allows the operator to again enter the user input interview subroutine in order to work on the model predictions for a different set of input parameters. Figures 4, 5 and 6 illustrate several of the output plots of size distribution, extinction and absorption available from the program menu.

## CONCLUSION

An aerosol model has been developed which operates in the BASIC language on small desktop computer systems. Inputs to the model are simple meteorological measurements, and if they are not available to the operator, default values are automatically substituted for them. Model predictions include aerosol size distributions, optical extinction and absorption due to marine aerosols. These outputs are available in a number of different forms.

Table 1 — Data sources

| DESCRIPTION | GEOGRAPHIC LOCATION | INVESTIGATOR | INSTRUMENT | REFERENCE |
|---|---|---|---|---|
| USNS HAYES (1977) | N. ATLANTIC<br>MEDITERRANEAN | U. KATZ<br>E. MACK<br>R. JECK<br>G. TRUSTY<br>T. COSDEN<br>W. HOPPEL | EAA<br>ROYCO<br>PMS-ASSP<br>PMS-ASASP<br>PMS-CSASP<br>NRL-MSS | GATHMAN & JULIAN (1979) |
| USNS HAYES (1980) | N. ATLANTIC | W. HOPPEL | NRL-MSS<br>ROYCO | unpublished |
| ADMIRAL FITZROY (1978) | N. ATLANTIC | G. TRUSTY<br>T. COSDEN | PMS-ASASP<br>PMS-CSASP | TRUSTY & COSDEN (1981) |
| SAN NICOLAS ISLAND, CA (1979) | PACIFIC | D. JENSEN<br>R. JECK<br>G. TRUSTY<br>G. SCHACHER | 11 PMS SPECTRO-METERS | JENSEN ET. AL. (1980) |
| SAN NICOLAS ISLAND, CA MAY 1979 | PACIFIC | R. JECK | PMS-ASSP | BLANC (1982) |

Table 1 (Cont'd) — Data sources

| DESCRIPTION | GEOGRAPHIC LOCATION | INVESTIGATOR | INSTRUMENT | REFERENCE |
|---|---|---|---|---|
| FPN (1979) | NORTH SEA | S. GATHMAN | ROYCO | GATHMAN & JULIAN |
| | | B. JULIAN | | (1980) |
| R/V ACANIA | PACIFIC | E. MACK | EAA | |
| (CEWCOM-78) | | T. NIZIOL | ROYCO | |
| | | C. ROGERS | | MACK ET. AL. |
| | | C. AKERS | | (1979) |

PMS=Particle Measuring System Inc. instrument family
EAA=Thermo-Systems Electrical Aerosol Analyzer
MSS=The NRL mobility size spectrometer, Hoppel (1978)
FPN=Forschungplattform Nordsee

Table II — Correlation matrix

| | AVE WIND | MEAS WIND |
|---|---|---|
| A1 PARAMETER | -0.260 | -0.168 |
| A2 PARAMETER | +0.639 | +0.595 |
| A3 PARAMETER | +0.727 | +0.761 |

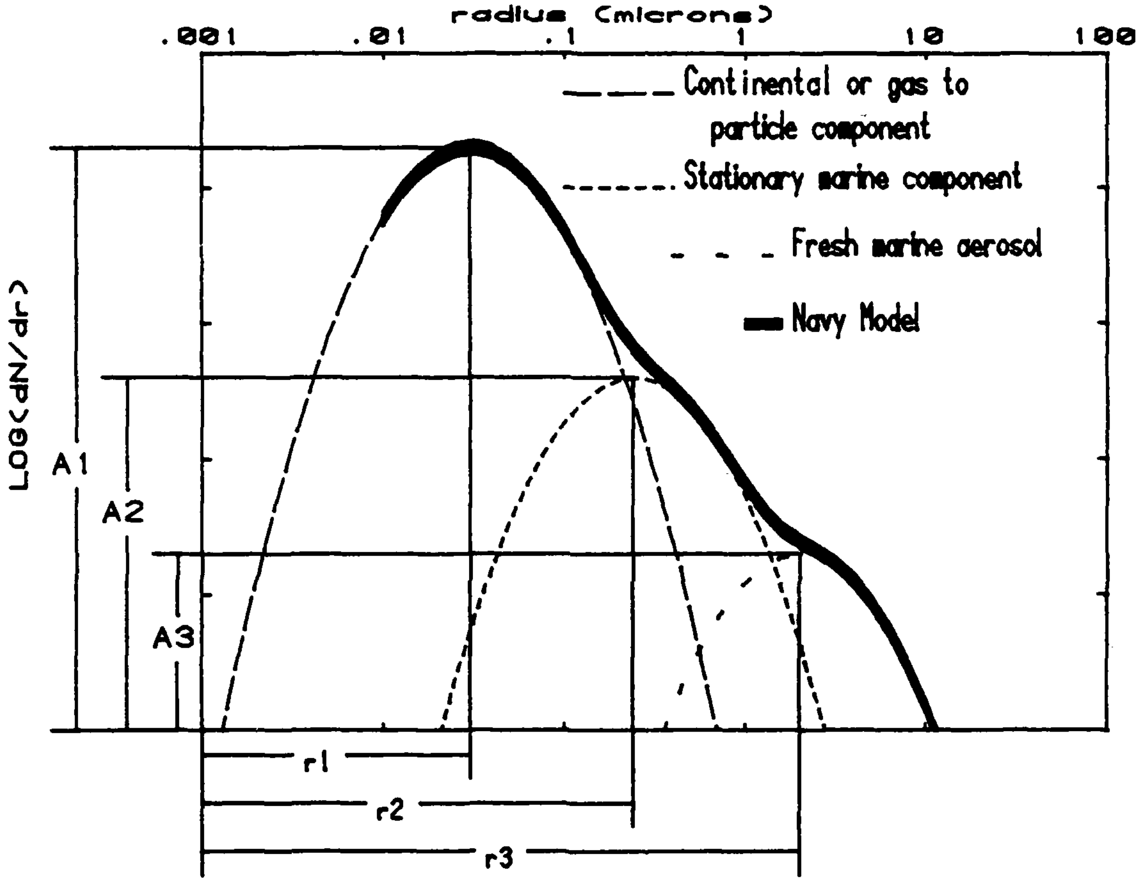



Figure 1. Idealized Navy Marine Aerosol Model

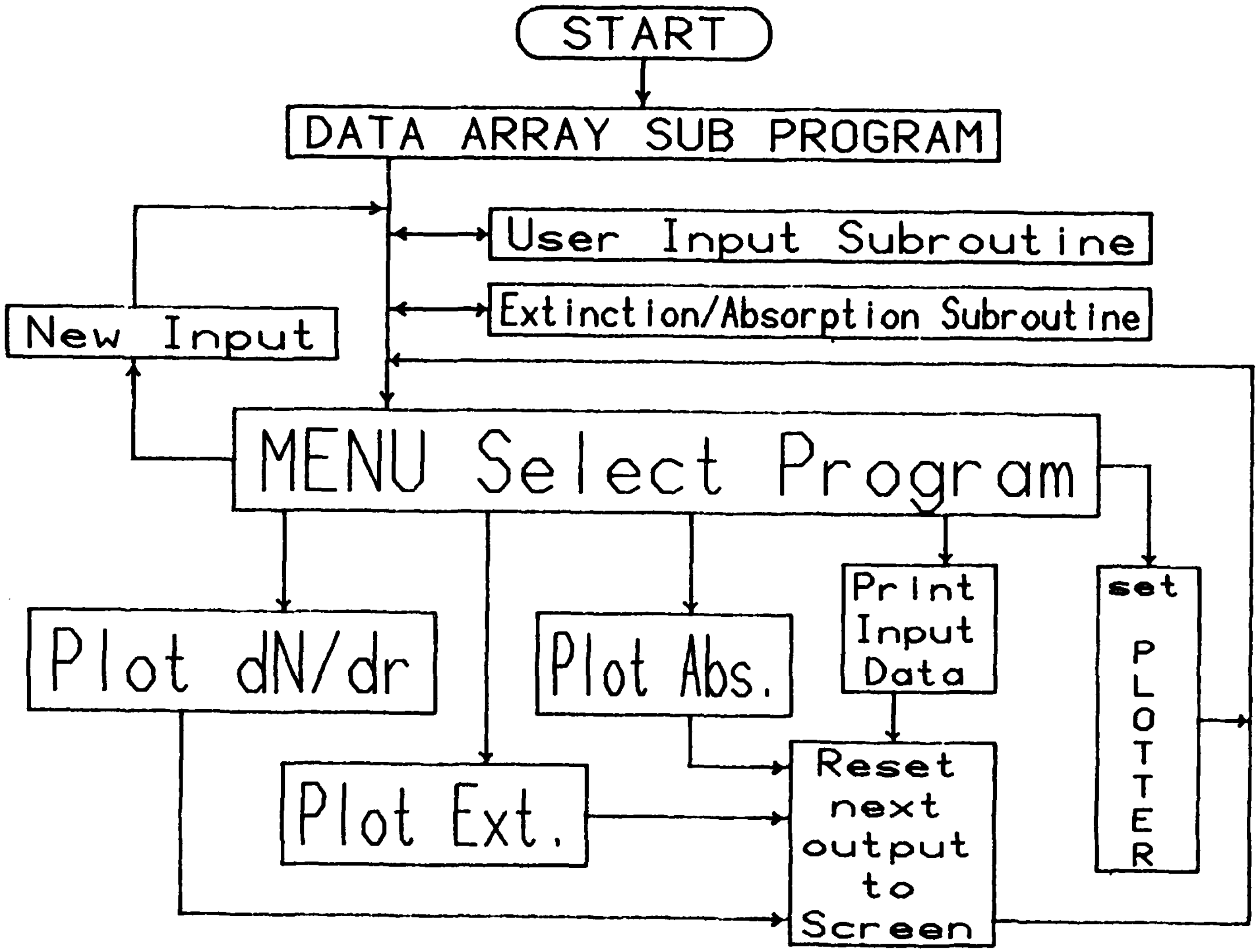



Figure 2. Flow Chart Showing General Flow of the Progress

1) Extinction and absorption of individual wavelengths

2) Plot of dN/dR vrs wavelength

3) Plot of extinction vrs wavelength

4) Plot of absorption vrs wavelength

5) Save extinction and absorption data on tape

6) New interactive input

7) Print input parameters

8) Send next output to plotter

9) Stop operations

please enter number of desired operation

Figure 3. Menu Selection Routine Display

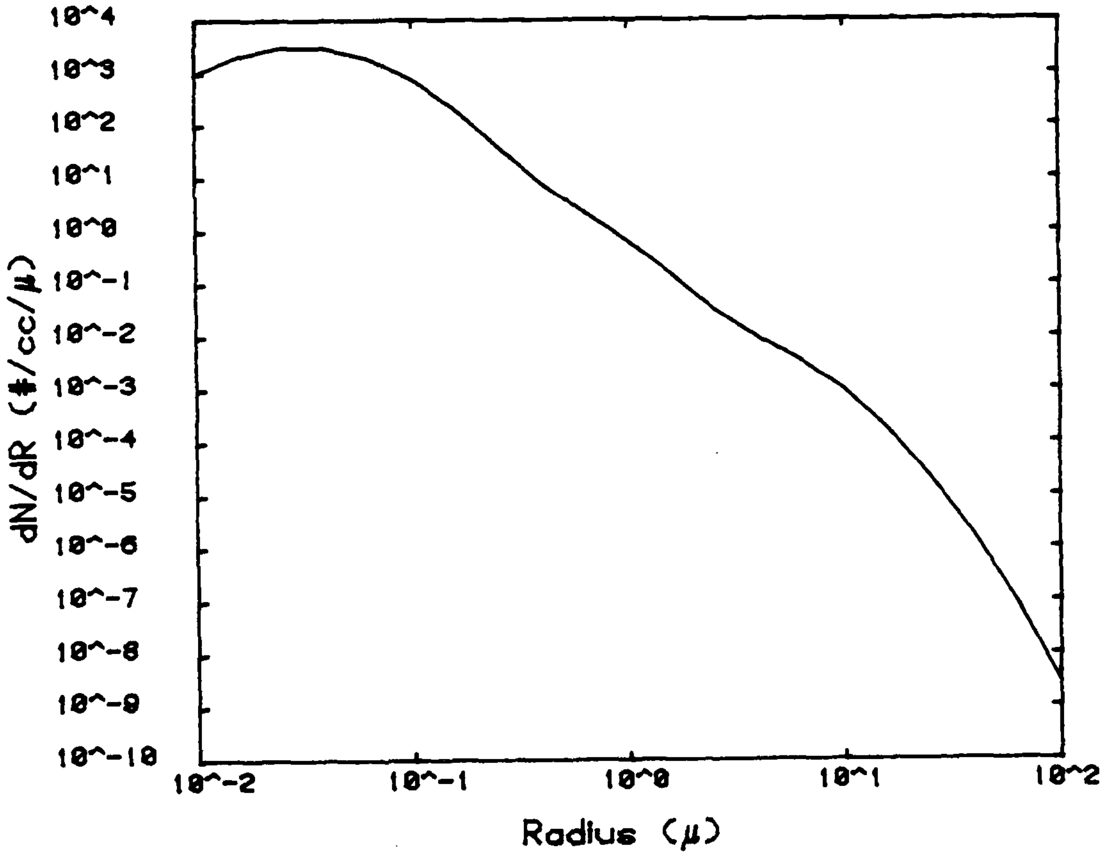



Figure 4. The Aerosol Size Distribution Function Available for Display - with Default Inputs.

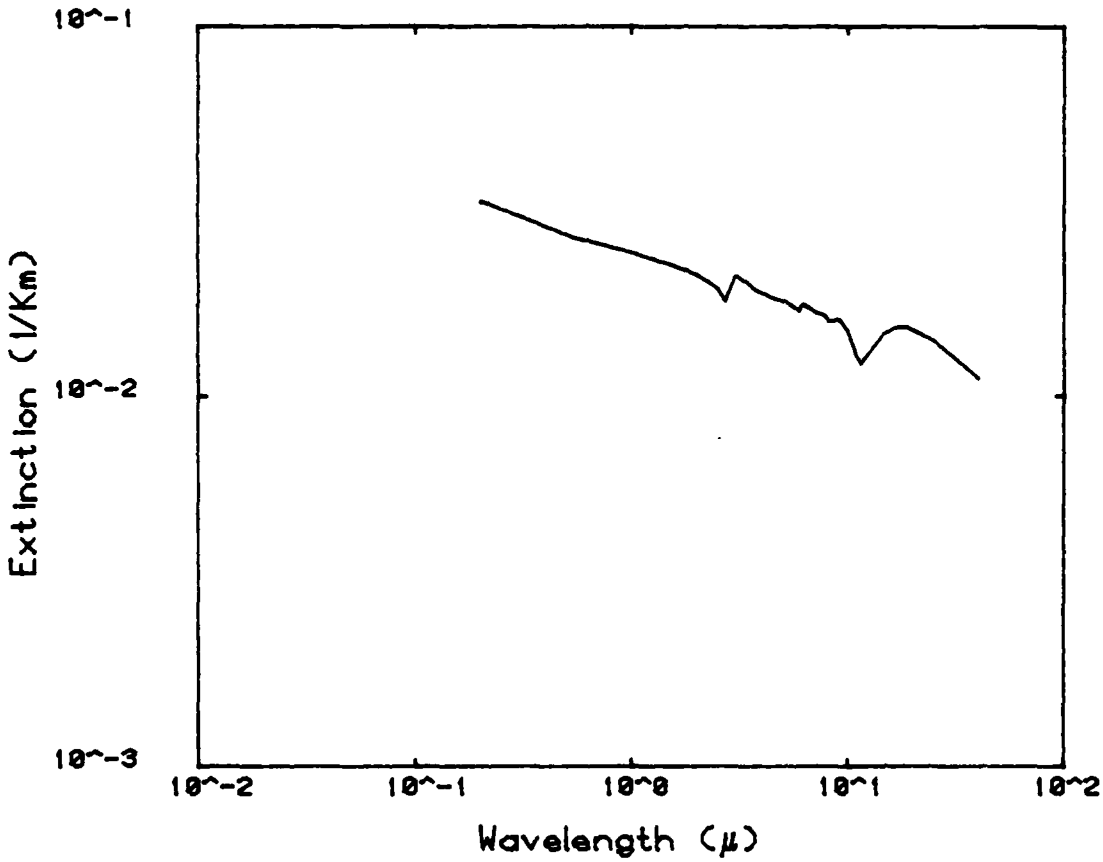



Figure 5. The Plot of Extinction VRS Wavelength Available for Display - with Default Inputs.

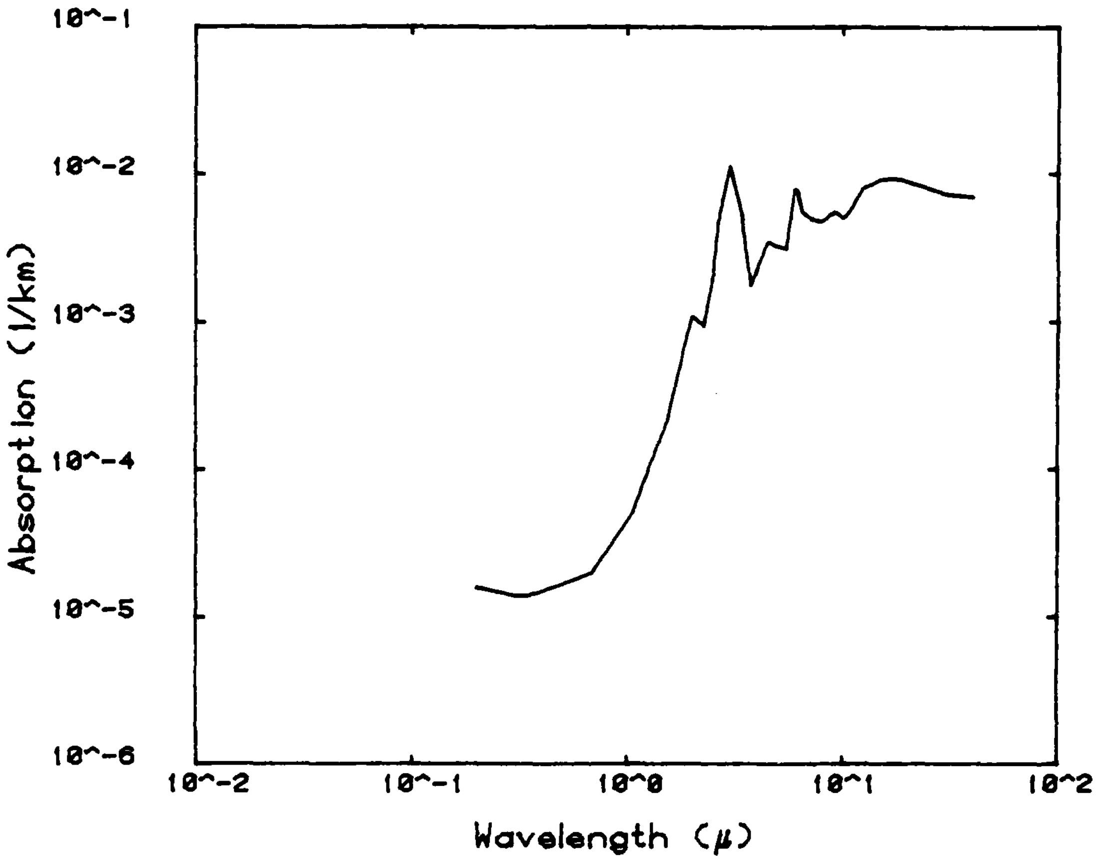



Figure 6. The Plot of Absorption VRS Wavelength Available for Display - with Default Inputs.

REFERENCES

Allan, R.R. and P.C. Ashdown (1982) "A note on the response of Knollenberg aerosol counters", J. Phys. D: appl. phys., 15, L59-L63.

Blanc, T.V. (1982) "The Data Base for the May 1979 Marine Surface Layer Micrometeorological Experiment at San Nicolas, Island, California", NRL Memorandum Report #4713. AD-A116-210.

Dave, J.V. (1968) "Subroutines for Computing the Parameters of Electromagnetic Radiation Scattered by a Sphere" IBM Palo Alto Scientific Center Report #320-3237, 67 pp.

Deepak, A. and L.H. Ruhnke, editors (1982) "Proceedings of Workshop on Hygroscopic Aerosols in the Planetary Boundary Layer"; Spectrum Press, Hampton, VA, (in press).

Fitzgerald, J.W. (1978) "On the Growth of Aerosol Particles with Relative Humidity", NRL Memorandum Report #3847, AD-A062-416.

Gathman, S.G. and B. G. Julian, (1979), editors: "The EOMET Cruise of the USNS HAYES: May-June 1977", NRL Memorandum Report #3924, 315 pp.

Gathman, S.G. and B.G. Julian (1980) "Passive 19.3 GHz Radiometer and Aerosol Data from the North Sea During MARSEN I - September-October 1979", NRL Memorandum Report #4285, 111 pp. AD-A088-229.

Hale, G.M. and M.R. Query (1973) "Optical constants of water in the 200 nm to 200-$\mu$m wavelength region", Applied Optics, 12, pp. 555-563.55-563.

Hanel, G. (1971) "New results concerning the dependence of visibility on relative humidity and their significance in a model for visibility forecast", Contrib. Atmos. Phys., Vol 44, p 137-167.

Hoppel, W.A. (1978) "Determination of the aerosol size distribution from the mobility distri ution of the charged fraction of aerosols", JAS, Vol 9, p 41-54.

Hoppel, W.A. (1979) "Measurement of the Size Distribution and CCN Supersaturation Spectrum of Submicron Aerosols over the Ocean", JAS, Vol 36, p 2006-1015.

Hoppel, W.A. (1981) "Measurement of Size Distribution and Solubility of Submicron Particles" in "Atmospheric Aerosols: Their Formation, Optical Properties, and Effects" edited by A. Deepak, Spectrum Press, Hampton, VA.

Hoppel, W.A. (1982) private communication.

Jensen, D., R. Jeck, G. Trusty, and G. Schacher (1980) "Intercomparison of PMS Particle Size Spectrometers", NOSC Technical Report #555, 53 pp.

Larson, R.E., and B.J. Bressan (1980) "Air Mass Characteristics over Coastal Areas as Determined by Radon Measurements", preprint vol: Second Conference on Coastal Meteorology, Jan 30 - Feb 1, 1980, Los Angeles, CA, published by A.M.S., Boston, MA.

Mack, E.J., T.A. Niziol, C.W. Rogers, and C.K. Akers (1979) "Meteorological and Aerosol Characteristics of the Marine Boundary Layer in the Vicinity of San Nicolas Island during CEWCOM-78" Calspan Report #6437-M-1.

Pinnick, R.G. and H.J. Auvermann, (1979) "Response characteristics of Knollenberg light scattering aerosol counters", J. Aerosol Sci., 10, p 55-74.

Trusty, G.L. and T.S. Cosden (1981) "Optical Extinction Predictions from Measurements aboard a British Weather Ship", NRL Report #8497, 46 pp. AD-A013-624.

Volz, F.E. (1972) "Infrared refractive index of atmospheric aerosol substances", Appl. Opt., Vol 11, pp 755-759.

APPENDIX I

```
100 INIT
110 U9=32
120 REM SET UP DATA ARRAYS
130 GOSUB 2990
140 REM INPUT MET DATA AND CALCULATE AMPLITUDES
150 GOSUB 1840
160 GOSUB 450
170 REM MENU SELECT FOR INTERACTIVE MODE
180 PAGE
190 PRINT "                          MENU"
200 PRINT "1)   Extinction and absorption of individual wavelengths"
210 PRINT
220 PRINT "2)   Plot of dN/dR vrs wavelength"
230 PRINT
240 PRINT "3)   Plot of extinction vrs wavelength"
250 PRINT
260 PRINT "4)   Plot of absorption vrs wavelength"
270 PRINT
280 PRINT "5)   Save extinction and absorption data on tape"
290 PRINT
300 PRINT "6)   New interactive input"
310 PRINT
320 PRINT "7)   Print input parameters"
330 PRINT
340 PRINT "8)   Send next output to plotter"
350 PRINT
360 PRINT "9)   Stop operations"
370 PRINT
380 PRINT "    please enter number of desired operation"
390 INPUT I
400 GOSUB I OF 750,1130,5670,5800,5920,140,6240
410 IF I=8 THEN 6330
420 IF I=9 THEN 6350
430 U9=32
440 GO TO 170
450 REM
460 REM  :-------------------------------------:
470 REM  :    Extinction/Absorption            :
480 REM  :          Subroutine                 :
490 REM  :-------------------------------------:
500 DIM Y7(40),Y8(40)
510 FOR I=1 TO 40
520 FOR J=2 TO 4
530 IF R9=R(J) THEN 560
540 IF R9<R(J) THEN 600
550 NEXT J
560 Y7(I)=(A1*10^T1(I,J)+A2*10^T2(I,J)+A3*10^T3(I,J))/F
570 Y8(I)=(A1*10^E1(I,J)+A2*10^E2(I,J)+A3*10^E3(I,J))/F
580 GO TO 710
590 REM INTERPOLATION FOR RELATIVE HUMIDITY
600 D6=R(J)-R(J-1)
610 D5=R9-R(J-1)
620 R5=D5/D6
630 X1=T1(I,J-1)+(T1(I,J)-T1(I,J-1))*R5
640 X2=T2(I,J-1)+(T2(I,J)-T2(I,J-1))*R5
```

```
650 X3=T3(I,J-1)+(T3(I,J)-T3(I,J-1))*R5
660 B1=E1(I,J-1)+(E1(I,J)-E1(I,J-1))*R5
670 B2=E2(I,J-1)+(E2(I,J)-E2(I,J-1))*R5
680 B3=E3(I,J-1)+(E3(I,J)-E3(I,J-1))*R5
690 Y7(I)=(A1*10^X1+A2*10^X2+A3*10^X3)/F
700 Y8(I)=(A1*10^B1+A2*10^B2+A3*10^B3)/F
710 NEXT I
720 Y7=1.0E-3*PI*Y7
730 Y8=1.0E-3*PI*Y8
740 RETURN
750 REM
760 REM     :-----------------------------------------------------:
770 REM     :               Extinction and absorption              :
780 REM     :               of individual wavelengths              :
790 REM     :                      subroutine                      :
800 REM     :-----------------------------------------------------:
810 PAGE
820 IO=0
830 PRINT "what wavelength?"
840 INPUT LO
850 IF LO<L(1) THEN 1110
860 IF LO>L(40) THEN 1110
870 FOR I=1 TO 39
880 IF LO=L(I) THEN 920
890 IF LO<L(I) OR LO>L(I+1) THEN 930
900 IO=I
910 GO TO 930
920 IO=-1*I
930 NEXT I
940 IF IO>0 THEN 1050
950 IO=-1*IO
960 EO=Y7(IO)
970 AO=Y8(IO)
980 PRINT "WAVELENGTH ";LO;" MICRONS"
990 PRINT "EXTINCTION ";EO;" KM^-1"
1000 PRINT "ABSORPTION ";AO;" KM^-1"
1010 PRINT "press [return] to continue"
1020 INPUT O$
1030 RETURN
1040 REM WAVELENGTH INTERPOLATION
1050 A=Y7(IO+1)-Y7(IO)
1060 B=Y8(IO+1)-Y8(IO)
1070 C=L(IO+1)-L(IO)
1080 EO=Y7(IO)+A*(LO-L(IO))/C
1090 AO=Y8(IO)+B*(LO-L(IO))/C
1100 GO TO 980
1110 PRINT "WAVELENGTH OUT OF RANGE OF MODEL"
1120 GO TO 770
1130 REM
1140 REM    :------------------------------------:
1150 REM    :    PLOT OF DN/DR VRS WAVELENGTH     :
1160 REM    :             subroutine              :
1170 REM    :                                     :
1180 REM    :------------------------------------:
1190 DEF FNA(X)=A1*EXP(-1*LOG(X/(0.03*F))^2)/F
```

```
1200 DEF FNB(X)=A2*EXP(-1*LOG(X/(0.24*F))^2)/F
1210 DEF FNC(X)=A3*EXP(-1*LOG(X/(2*F))^2)/F
1220 DEF FND(X)=FNA(X)+FNB(X)+FNC(X)
1230 REM FIND Y LIMITS
1240 Y9=1.0E-99
1250 Y0=1.0E+99
1260 FOR I=-2 TO 2 STEP 0.25
1270 X=10^I
1280 Y9=FND(X) MAX Y9
1290 Y0=FND(X) MIN Y0
1300 NEXT I
1310 Y9=INT(LGT(Y9))+1
1320 Y0=INT(LGT(Y0))-1
1330 REM PLOT GRAPH OF FUNCTION D
1340 GOSUB 1380
1350 GOSUB 1630
1360 RETURN
1370 REM
1380 PAGE
1390 VIEWPORT 20,110,10,90
1400 WINDOW -2,2,Y0,Y9
1410 AXIS @U9:1,1,-2,Y0
1420 AXIS @U9:1,1,2,Y9
1430 MOVE @U9:-2,FND(0.01)
1440 FOR I=-2 TO 2 STEP 0.2
1450 X=10^I
1460 Y=LGT(FND(X))
1470 DRAW @U9:I,Y
1480 NEXT I
1490 REM TIC MARK LABLE ROUTINE
1500 VIEWPORT 0,130,0,100
1510 WINDOW 0,130,0,100
1520 DEF FNX(X)=20+90*(X+2)/4
1530 DEF FNY(Y)=10+80*(Y-Y0)/(Y9-Y0)
1540 FOR Y=Y0 TO Y9
1550 MOVE @U9:5,FNY(Y)
1560 PRINT @U9:"10^";Y-1
1570 NEXT Y
1580 FOR X=-2 TO 2
1590 MOVE @U9:FNX(X)-3,7
1600 PRINT @U9:"10^";X
1610 NEXT X
1620 RETURN
1630 T$="SIZE DISTRIBUTION PLOT"
1640 X$="Radius ([)"
1650 Y$="dN/dR (#/cc/[)"
1660 REM PLOT LABEL ROUTINE
1670 SET DEGREES
1680 CALL "LROT",0
1690 CALL "LSIZE",2,3
1700 MOVE @U9:65,93
1710 CALL "LMOVE",U9;-LEN(T$)/2,0
1720 CALL "LETEVN",U9;T$
1730 MOVE @U9:65,1
1740 CALL "LSIZE",1.5,2.5
```

```
1750 CALL "LMFONT", 12
1760 CALL "LMOVE", U9; -LEN(X$)/2, 0
1770 CALL "LETEVN", U9; X$
1780 MOVE @U9: 3, 50
1790 CALL "LROT", 90
1800 CALL "LMOVE", U9; -LEN(Y$)/2, 0
1810 CALL "LETEVN", U9; Y$
1820 INPUT O$
1830 RETURN
1840 REM
1850 REM  :-----------------------------------------:
1860 REM  :       USER INPUT PROGRAM                 :
1870 REM  :                                          :
1880 REM  :-----------------------------------------:
1890 PAGE
1900 A$="The five zonal catagories are: "
1910 IMAGE18T, 50A, //
1920 PRINT USING 1910: A$
1930 PRINT "      1)---TROPICAL"
1940 PRINT "      2)---MIDLATITUDE SUMMER"
1950 PRINT "      3)---MIDLATITUDE WINTER"
1960 PRINT "      4)---SUBARTIC SUMMER"
1970 PRINT "      5)---SUBARTIC WINTER"
1980 PRINT
1990 PRINT "INPUT THE NUMBER OF THE CATAGORY FOR THIS CALCULATION: ";
2000 INPUT CO
2010 IF CO>5 THEN 1900
2020 IF CO<0 THEN 1900
2030 CO=INT(CO)
2040 PAGE
2050 PRINT "INPUT A NUMBER BETWEEN 1 AND 10 WHICH DESCRIBES"
2060 PRINT "THE AIR MASS --1 = PURE OCEANIC,  10= COASTAL"
2070 INPUT A9
2080 A1=2000*A9^2
2090 PAGE
2100 PRINT "      Input the 24 hour average wind speed in m/s"
2110 PRINT "            (The model range is 0 to 20 m/s)"
2120 PRINT "               [ hit ""return"" if default ]"
2130 INPUT A$
2140 IF A$="" THEN 2190
2150 WO=VAL(A$)
2160 IF WO>20 THEN 2090
2170 IF WO<0 THEN 2090
2180 GO TO 2290
2190 GOSUB CO OF 2210, 2210, 2230, 2250, 2270
2200 GO TO 2290
2210 WO=4. 1
2220 RETURN
2230 WO=10. 29
2240 RETURN
2250 WO=6. 69
2260 RETURN
2270 WO=12. 3466
2280 RETURN
2290 PAGE
```

```
2300 PRINT "      Input the wind speed (m/s) at time of calculation"
2310 PRINT "             (The model range is 0 to 20 m/s)"
2320 PRINT "                 [ hit ""return"" if default ]"
2330 INPUT A$
2340 IF A$="" THEN 2390
2350 W9=VAL(A$)
2360 IF W9>20 THEN 2290
2370 IF W9<0 THEN 2290
2380 GO TO 2430
2390 W8=W0
2400 GOSUB C0 OF 2210,2210,2230,2250,2270
2410 W9=W0
2420 W0=W8
2430 PAGE
2440 PRINT "      Input the relative humidity (%) at time of calculation"
2450 PRINT "                    ( The model range is 50 to 98 %)"
2460 PRINT "                     [ hit ""return"" if default ]"
2470 INPUT A$
2480 IF A$="" THEN 2530
2490 R9=VAL(A$)
2500 IF R9>98 THEN 2430
2510 IF R9<50 THEN 2430
2520 GO TO 2540
2530 R9=80
2540 F=((2-R9/100)/(6*(1-R9/100)))^0.333333
2550 A2=0.5 MAX 5.866*(W0-2.2)
2560 A3=1.14E-5 MAX 0.01527*(W9-2.2)
2570 PAGE
2580 PRINT " Input the visibility (km) at the time of the measurement"
2590 PRINT "               ( The model range is .8 to 80 km )"
2600 PRINT "                 [ hit ""return"" if default ]"
2610 C=1
2620 INPUT A$
2630 IF A$="" THEN 2710
2640 V9=VAL(A$)
2650 V$=A$
2660 IF V9>80 THEN 2570
2670 IF V9<0.8 THEN 2570
2680 REM
2690 REM FIND  EXTINCTION COEFFICIENTS FOR CURRENT RH AT .55 MICRONS
2700 REM
2710 J=4
2720 FOR I=2 TO 4
2730 IF R9=R(I) THEN 2780
2740 IF R9<R(I) THEN 2800
2750 NEXT I
2760 Q1=T1(J,I)
2770 Q2=T2(J,I)
2780 Q3=T3(J,I)
2790 GO TO 2860
2800 D6=R(I)-R(I-1)
2810 D5=R9-R(I-1)
2820 R5=D5/D6
2830 Q1=T1(J,I-1)+(T1(J,I)-T1(J,I-1))*R5
2840 Q2=T2(J,I-1)+(T2(J,I)-T2(J,I-1))*R5
```

```
2850 Q3=T3(J,I-1)+(T3(J,I)-T3(J,I-1))*R5
2860 S5=A1*10^Q1+A2*10^Q2+A3*10^Q3
2870 IF A$="" THEN 2950
2880 S0=3.912/V9
2890 S1=1.0E-3*PI*S5/F
2900 C=S0/S1
2910 A1=C*A1
2920 A2=C*A2
2930 A3=C*A3
2940 RETURN
2950 V9=3912/(PI*S5/F)
2960 V$=STR(V9)
2970 RETURN
2980 REM
2990 REM
3000 REM  :-----------------------------------------------------:
3010 REM  :                                                     :
3020 REM  :           Data Array Input Subroutine               :
3030 REM  :-----------------------------------------------------:
3040 PAGE
3050 DIM T1(40,4),T2(40,4),T3(40,4)
3060 DIM E1(40,4),E2(40,4),E3(40,4)
3070 DIM L(40),R(4)
3080 READ L,R
3090 FOR I=1 TO 4
3100 FOR J=1 TO 40
3110 READ T1(J,I)
3120 NEXT J
3130 NEXT I
3140 FOR I=1 TO 4
3150 FOR J=1 TO 40
3160 READ T2(J,I)
3170 NEXT J
3180 NEXT I
3190 FOR I=1 TO 4
3200 FOR J=1 TO 40
3210 READ T3(J,I)
3220 NEXT J
3230 NEXT I
3240 FOR I=1 TO 4
3250 FOR J=1 TO 40
3260 READ E1(J,I)
3270 NEXT J
3280 NEXT I
3290 FOR I=1 TO 4
3300 FOR J=1 TO 40
3310 READ E2(J,I)
3320 NEXT J
3330 NEXT I
3340 FOR I=1 TO 4
3350 FOR J=1 TO 40
3360 READ E3(J,I)
3370 NEXT J
3380 NEXT I
3390 REM
```

```
3400 REM   MARINE AEROSOL EXTINCTION AND ABSORPTION DATA
3410 REM
3420 REM DATA ALAM(I)
3430 DATA 0. 2, 0. 3, 0. 3371, 0. 55, 0. 6943, 1. 06, 1. 536
3440 DATA 2, 2. 25, 2. 5, 2. 7, 3, 3. 3923, 3. 75
3450 DATA 4. 5, 5, 5. 5, 6, 6. 2, 6. 5, 7. 2
3460 DATA 7. 9, 8. 2, 8. 7, 9, 9. 2, 10, 10. 591
3470 DATA 11, 11. 5, 12. 5, 14. 8, 15, 16. 4, 17. 2
3480 DATA 18. 5, 21. 3, 25, 30, 40
3490 DATA 50, 85, 95, 99
3500 REM DATA T1QEXT(I1)
3510 DATA -3. 29185, -3. 46591, -3. 52736, -3. 85047, -4. 03868
3520 DATA -4. 44102, -4. 85824, -5. 17191, -5. 32721, -5. 43408
3530 DATA -5. 27651, -4. 51014, -5. 37299, -5. 74669, -5. 75791
3540 DATA -5. 8333, -5. 85518, -5. 17797, -5. 29098, -5. 59589
3550 DATA -5. 62952, -5. 67483, -5. 60509, -5. 53632, -5. 53301
3560 DATA -5. 51361, -5. 65681, -5. 60403, -5. 52207, -5. 39019
3570 DATA -5. 17243, -5. 09027, -5. 09009, -5. 12849, -5. 14443
3580 DATA -5. 1963, -5. 31009, -5. 39939, -5. 48733, -5. 47787
3590 REM DATA T1QEXT(I2)
3600 DATA -2. 82673, -2. 94428, -2. 99042, -3. 25094, -3. 41017
3610 DATA -3. 76374, -4. 14507, -4. 44655, -4. 61595, -4. 77713
3620 DATA -4. 70303, -3. 84609, -4. 64656, -5. 01036, -5. 07475
3630 DATA -5. 181, -5. 2705, -4. 55373, -4. 65936, -4. 9872
3640 DATA -5. 08721, -5. 12288, -5. 09852, -5. 06226, -5. 05439
3650 DATA -5. 04072, -5. 07925, -4. 97964, -4. 87484, -4. 72976
3660 DATA -4. 50629, -4. 42596, -4. 42795, -4. 46498, -4. 49119
3670 DATA -4. 54736, -4. 66716, -4. 77106, -4. 88137, -4. 90731
3680 REM DATA T1QEXT(I3)
3690 DATA -2. 36735, -2. 4227, -2. 45109, -2. 63754, -2. 76251
3700 DATA -3. 05739, -3. 39166, -3. 66823, -3. 83041, -4. 01116
3710 DATA -4. 04669, -3. 2055, -3. 87167, -4. 1907, -4. 32822
3720 DATA -4. 44948, -4. 57799, -3. 92482, -4. 0136, -4. 33492
3730 DATA -4. 46737, -4. 50881, -4. 5083, -4. 4973, -4. 49229
3740 DATA -4. 48452, -4. 47532, -4. 36167, -4. 25084, -4. 10285
3750 DATA -3. 87792, -3. 79631, -3. 7989, -3. 83449, -3. 86388
3760 DATA -3. 92151, -4. 04376, -4. 15314, -4. 27189, -4. 31195
3770 REM DATA T1QEXT(I4)
3780 DATA -1. 98737, -1. 99835, -2. 01235, -2. 13388, -2. 22731
3790 DATA -2. 46709, -2. 75498, -3. 00366, -3. 15269, -3. 333
3800 DATA -3. 44686, -2. 6649, -3. 19849, -3. 4768, -3. 6571
3810 DATA -3. 78212, -3. 92845, -3. 37763, -3. 4435, -3. 74357
3820 DATA -3. 89103, -3. 9455, -3. 95731, -3. 96333, -3. 96389
3830 DATA -3. 96098, -3. 94271, -3. 83041, -3. 72029, -3. 57329
3840 DATA -3. 34893, -3. 26494, -3. 26753, -3. 30171, -3. 33166
3850 DATA -3. 38928, -3. 51255, -3. 62432, -3. 74666, -3. 79274
3860 REM DATA T2QEXT(I1)
3870 DATA -0. 57638, -0. 55482, -0. 54621, -0. 51717, -0. 50455
3880 DATA -0. 53459, -0. 61338, -0. 71343, -0. 7778, -0. 86189
3890 DATA -0. 98393, -0. 77201, -0. 85393, -0. 95354, -1. 0873
3900 DATA -1. 16239, -1. 2647, -1. 21231, -1. 18111, -1. 29044
3910 DATA -1. 4126, -1. 46425, -1. 52265, -1. 45596, -1. 41773
3920 DATA -1. 41437, -1. 57463, -1. 63481, -1. 64309, -1. 6023
3930 DATA -1. 46481, -1. 39102, -1. 38979, -1. 40561, -1. 41958
3940 DATA -1. 46545, -1. 57948, -1. 6825, -1. 79237, -1. 82243
```

```
3950 REM DATA T2GEXT(I2)
3960 DATA -0. 17855, -0. 1626, -0. 15814, -0. 12737, -0. 10598
3970 DATA -0. 1067, -0. 14685, -0. 21614, -0. 2679, -0. 34788
3980 DATA -0. 4988, -0. 26573, -0. 29892, -0. 39244, -0. 52662
3990 DATA -0. 59831, -0. 70364, -0. 66706, -0. 60739, -0. 71336
4000 DATA -0. 83517, -0. 90798, -0. 95766, -0. 95786, -0. 95417
4010 DATA -0. 96293, -1. 08663, -1. 12191, -1. 10319, -1. 03298
4020 DATA -0. 8663, -0. 76769, -0. 76667, -0. 77679, -0. 79188
4030 DATA -0. 83041, -0. 93543, -1. 03999, -1. 16395, -1. 23571
4040 REM DATA T2GEXT(I3)
4050 DATA 0. 24939, 0. 25892, 0. 26319, 0. 28946, 0. 31271
4060 DATA 0. 32944, 0. 32595, 0. 29164, 0. 25885, 0. 1987
4070 DATA 0. 0548, 0. 23218, 0. 24883, 0. 18156, 0. 06856
4080 DATA 0. 00898, -0. 08457, -0. 08754, -0. 01103, -0. 09355
4090 DATA -0. 20136, -0. 27989, -0. 3215, -0. 35753, -0. 37685
4100 DATA -0. 39436, -0. 50179, -0. 53792, -0. 51793, -0. 44727
4110 DATA -0. 28219, -0. 17299, -0. 17129, -0. 17372, -0. 18497
4120 DATA -0. 21407, -0. 30457, -0. 4002, -0. 52213, -0. 61624
4130 REM DATA T2GEXT(I4)
4140 DATA 0. 62785, 0. 6347, 0. 63797, 0. 65886, 0. 67788
4150 DATA 0. 69969, 0. 71685, 0. 70872, 0. 69233, 0. 65439
4160 DATA 0. 53562, 0. 64735, 0. 69242, 0. 65156, 0. 56617
4170 DATA 0. 52059, 0. 44411, 0. 4091, 0. 49025, 0. 43258
4180 DATA 0. 34266, 0. 26912, 0. 23363, 0. 18727, 0. 15936
4190 DATA 0. 13859, 0. 03479, -0. 01309, -0. 00312, 0. 05656
4200 DATA 0. 2093, 0. 32139, 0. 32381, 0. 32787, 0. 3211
4210 DATA 0. 30075, 0. 2257, 0. 14267, 0. 03036, -0. 07385
4220 REM DATA T3GEXT(I1)
4230 DATA 2. 14251, 2. 14569, 2. 14659, 2. 15378, 2. 16101
4240 DATA 2. 1705, 2. 17829, 2. 19485, 2. 2029, 2. 21229
4250 DATA 2. 21476, 2. 19307, 2. 2217, 2. 23261, 2. 24192
4260 DATA 2. 24714, 2. 24905, 2. 22037, 2. 23832, 2. 24699
4270 DATA 2. 23805, 2. 23747, 2. 21785, 2. 23142, 2. 24214
4280 DATA 2. 24197, 2. 2236, 2. 19546, 2. 16835, 2. 13701
4290 DATA 2. 11929, 2. 14541, 2. 14777, 2. 17026, 2. 17246
4300 DATA 2. 17289, 2. 15782, 2. 13258, 2. 08785, 2. 01309
4310 REM DATA T3GEXT(I2)
4320 DATA 2. 54766, 2. 55027, 2. 55136, 2. 55712, 2. 5596
4330 DATA 2. 56779, 2. 5786, 2. 59064, 2. 59114, 2. 6033
4340 DATA 2. 60821, 2. 58746, 2. 60914, 2. 61829, 2. 63247
4350 DATA 2. 63954, 2. 64483, 2. 61385, 2. 63204, 2. 6444
4360 DATA 2. 6435, 2. 64163, 2. 63391, 2. 63307, 2. 63516
4370 DATA 2. 63303, 2. 6078, 2. 56796, 2. 534, 2. 5025
4380 DATA 2. 51223, 2. 56523, 2. 56813, 2. 58683, 2. 5925
4390 DATA 2. 5986, 2. 59462, 2. 58364, 2. 55669, 2. 49484
4400 REM DATA T3GEXT(I3)
4410 DATA 2. 982, 2. 98405, 2. 98393, 2. 98941, 2. 99057
4420 DATA 2. 99678, 3. 00629, 3. 0182, 3. 01574, 3. 02206
4430 DATA 3. 02942, 3. 01481, 3. 02942, 3. 03487, 3. 04926
4440 DATA 3. 05572, 3. 06352, 3. 041, 3. 05323, 3. 06532
4450 DATA 3. 07092, 3. 07306, 3. 07185, 3. 06985, 3. 06852
4460 DATA 3. 06621, 3. 04564, 3. 00668, 2. 9733, 2. 94597
4470 DATA 2. 96431, 3. 01557, 3. 0182, 3. 03362, 3. 03985
4480 DATA 3. 04774, 3. 051, 3. 05015, 3. 03846, 2. 99428
4490 REM DATA T3GEXT(I4)
```

```
4500 DATA 3.36297,3.36494,3.36504,3.36855,3.37122
4510 DATA 3.37532,3.38374,3.39303,3.3912,3.39429
4520 DATA 3.39997,3.39104,3.40164,3.40463,3.41622
4530 DATA 3.42129,3.42869,3.41479,3.4222,3.43177
4540 DATA 3.43913,3.44408,3.44545,3.44626,3.44576
4550 DATA 3.44495,3.43287,3.40162,3.37194,3.34676
4560 DATA 3.36173,3.40459,3.4068,3.41974,3.42552
4570 DATA 3.43335,3.44009,3.44478,3.4429,3.41435
4580 REM DATA T1GABS(I1)
4590 DATA -7.75592,-7.85066,-7.86246,-7.84952,-7.78875
4600 DATA -7.5044,-7.00578,-6.39548,-6.32102,-6.00259
4610 DATA -5.41761,-4.54426,-5.63799,-6.26352,-5.95117
4620 DATA -5.98603,-5.95257,-5.19071,-5.31151,-5.62888
4630 DATA -5.65018,-5.69225,-5.6157,-5.54615,-5.54368
4640 DATA -5.52339,-5.66468,-5.60869,-5.525,-5.39183
4650 DATA -5.17326,-5.09089,-5.0907,-5.12912,-5.14501
4660 DATA -5.19684,-5.3105,-5.39967,-5.4875,-5.47793
4670 REM DATA T1GABS(I2)
4680 DATA -7.58565,-7.69674,-7.70983,-7.68863,-7.62211
4690 DATA -7.27888,-6.66364,-5.91165,-6.03513,-5.62914
4700 DATA -4.88134,-3.89466,-5.02361,-5.76068,-5.33902
4710 DATA -5.40521,-5.43349,-4.57106,-4.69099,-5.04001
4720 DATA -5.12628,-5.1522,-5.11995,-5.07969,-5.07079
4730 DATA -5.05537,-5.0883,-4.98418,-4.87749,-4.73128
4740 DATA -4.50735,-4.42705,-4.42905,-4.46609,-4.49225
4750 DATA -4.54835,-4.66793,-4.7716,-4.88174,-4.90742
4760 REM DATA T1GABS(I3)
4770 DATA -7.38312,-7.53529,-7.54723,-7.51929,-7.443
4780 DATA -6.96867,-6.19332,-5.33729,-5.62617,-5.13276
4790 DATA -4.29356,-3.27844,-4.38954,-5.17693,-4.71507
4800 DATA -4.79439,-4.8513,-3.95413,-4.06976,-4.42961
4810 DATA -4.54436,-4.56471,-4.55326,-4.53199,-4.52244
4820 DATA -4.5111,-4.48986,-4.3685,-4.2548,-4.10527
4830 DATA -3.87999,-3.79874,-3.80132,-3.83693,-3.86627
4840 DATA -3.92376,-4.04557,-4.15447,-4.27275,-4.31227
4850 REM DATA T1GABS(I4)
4860 DATA -7.1585,-7.37341,-7.40367,-7.37245,-7.2835
4870 DATA -6.61384,-5.71359,-4.80886,-5.18296,-4.64071
4880 DATA -3.77116,-2.76442,-3.83618,-4.64254,-4.17236
4890 DATA -4.25724,-4.32629,-3.42492,-3.53414,-3.89616
4900 DATA -4.02218,-4.04208,-4.03854,-4.0258,-4.01692
4910 DATA -4.00765,-3.96758,-3.84194,-3.727,-3.57756
4920 DATA -3.35289,-3.26973,-3.27234,-3.30657,-3.33649
4930 DATA -3.39398,-3.5164,-3.62722,-3.74861,-3.79347
4940 REM DATA T2GABS(I1)
4950 DATA -4.15262,-4.21064,-4.03433,-4.13825,-4.04078
4960 DATA -3.7249,-3.20207,-2.59098,-2.52207,-2.2234
4970 DATA -1.71005,-1.02431,-1.81764,-2.43039,-2.14834
4980 DATA -2.18966,-2.17682,-1.50249,-1.577,-1.8688
4990 DATA -1.91321,-1.95495,-1.90229,-1.82005,-1.80195
5000 DATA -1.7822,-1.94154,-1.90823,-1.84194,-1.72902
5010 DATA -1.5359,-1.45231,-1.45109,-1.47445,-1.48752
5020 DATA -1.53387,-1.64461,-1.73767,-1.83378,-1.8404
5030 REM DATA T2GABS(I2)
5040 DATA -4.0384,-4.0927,-4.0724,-4.02179,-3.91999
```

```
5050 DATA -3. 5309, -2. 88921, -2. 1311, -2. 25397, -1. 8678
5060 DATA -1. 21144, -0. 5112, -1. 22251, -1. 93111, -1. 55024
5070 DATA -1. 61892, -1. 66462, -0. 93278, -0. 98923, -1. 29212
5080 DATA -1. 39089, -1. 42359, -1. 40593, -1. 36663, -1. 35499
5090 DATA -1. 34284, -1. 39661, -1. 31981, -1. 23455, -1. 11468
5100 DATA -0. 92482, -0. 83319, -0. 8328, -0. 84903, -0. 86579
5110 DATA -0. 90721, -1. 01096, -1. 10879, -1. 22101, -1. 26423
5120 REM DATA T2QABS(I3)
5130 DATA -3. 82641, -3. 96839, -3. 95005, -3. 88223, -3. 69519
5140 DATA -3. 26018, -2. 45203, -1. 58511, -1. 86605, -1. 39179
5150 DATA -0. 66023, -0. 02501, -0. 63041, -1. 36137, -0. 94405
5160 DATA -1. 0199, -1. 08903, -0. 36811, -0. 40882, -0. 69756
5170 DATA -0. 81403, -0. 84303, -0. 84097, -0. 82687, -0. 82079
5180 DATA -0. 81415, -0. 81764, -0. 73053, -0. 64464, -0. 53053
5190 DATA -0. 35344, -0. 25818, -0. 25736, -0. 26605, -0. 28015
5200 DATA -0. 31372, -0. 40463, -0. 49537, -0. 60632, -0. 66344
5210 REM DATA T2QABS(I4)
5220 DATA -3. 61901, -3. 75965, -3. 83627, -3. 71733, -3. 62226
5230 DATA -2. 91811, -2. 00247, -1. 08628, -1. 44431, -0. 92245
5240 DATA -0. 1746, 0. 37894, -0. 13258, -0. 85158, -0. 42675
5250 DATA -0. 50206, -0. 57708, 0. 10724, 0. 07795, -0. 18878
5260 DATA -0. 30608, -0. 33308, -0. 33609, -0. 33205, -0. 32886
5270 DATA -0. 32481, -0. 31228, -0. 22749, -0. 14687, -0. 0421
5280 DATA 0. 11926, 0. 21357, 0. 21498, 0. 21227, 0. 20197
5290 DATA 0. 176, 0. 09892, 0. 01903, -0. 08361, -0. 14374
5300 REM DATA T3QABS(I1)
5310 DATA -0. 52875, -0. 60403, -0. 59657, -0. 52127, -0. 40876
5320 DATA -0. 09838, 0. 44326, 1. 0381, 1. 11039, 1. 36487
5330 DATA 1. 71014, 1. 89028, 1. 65373, 1. 22626, 1. 47041
5340 DATA 1. 45252, 1. 47353, 1. 84278, 1. 82612, 1. 69134
5350 DATA 1. 67189, 1. 65672, 1. 68158, 1. 74161, 1. 76145
5360 DATA 1. 77375, 1. 68642, 1. 69835, 1. 72626, 1. 77322
5370 DATA 1. 84765, 1. 8953, 1. 89771, 1. 90997, 1. 91202
5380 DATA 1. 90737, 1. 88188, 1. 85563, 1. 81656, 1. 80328
5390 REM DATA T3QABS(I2)
5400 DATA -0. 41681, -0. 47303, -0. 48222, -0. 36557, -0. 31859
5410 DATA 0. 1051, 0. 74666, 1. 46534, 1. 37515, 1. 71513
5420 DATA 2. 14734, 2. 28083, 2. 13094, 1. 67666, 1. 98121
5430 DATA 1. 94611, 1. 92455, 2. 27485, 2. 26902, 2. 15933
5440 DATA 2. 11458, 2. 10322, 2. 11271, 2. 13811, 2. 14836
5450 DATA 2. 15579, 2. 12421, 2. 15345, 2. 18404, 2. 22259
5460 DATA 2. 27898, 2. 32467, 2. 32683, 2. 33872, 2. 34213
5470 DATA 2. 3439, 2. 33379, 2. 31998, 2. 29261, 2. 27503
5480 REM DATA T3QABS(I3)
5490 DATA -0. 23022, -0. 34184, -0. 35229, -0. 27286, -0. 17437
5500 DATA 0. 34512, 1. 15552, 1. 97897, 1. 74433, 2. 15897
5510 DATA 2. 61815, 2. 69993, 2. 60962, 2. 18492, 2. 49459
5520 DATA 2. 45849, 2. 4263, 2. 72037, 2. 7183, 2. 64016
5530 DATA 2. 59699, 2. 58936, 2. 59212, 2. 6012, 2. 60594
5540 DATA 2. 60919, 2. 60493, 2. 63335, 2. 65742, 2. 68431
5550 DATA 2. 72244, 2. 76007, 2. 76203, 2. 7734, 2. 77795
5560 DATA 2. 78319, 2. 78382, 2. 78109, 2. 76779, 2. 75712
5570 REM DATA T3QABS(I4)
5580 DATA -0. 02251, -0. 21831, -0. 2263, -0. 16391, -0. 06199
5590 DATA 0. 65388, 1. 58565, 2. 43873, 2. 13856, 2. 5914
```

```
5600 DATA 3.02465,3.06959,3.01494,2.63615,2.92693
5610 DATA 2.89506,2.86453,3.10261,3.10096,3.04743
5620 DATA 3.01322,3.00881,3.01,3.01448,3.01712
5630 DATA 3.01932,3.02333,3.04638,3.06352,3.08077
5640 DATA 3.10466,3.1337,3.13539,3.14576,3.1506
5650 DATA 3.15718,3.16385,3.16808,3.16516,3.16244
5660 RETURN
5670 REM    :----------------------------:
5680 REM    :  Extinction vrs wavelength  :
5690 REM    :    Plotting Subroutine      :
5700 REM    :                            :
5710 REM    :----------------------------:
5720 DIM Y6(40)
5730 Y6=Y7
5740 T$="EXTINCTION VRS WAVELENGTH PLOT"
5750 X$="Wavelength ([)"
5760 Y$="Extinction (1/Km)"
5770 GOSUB 6030
5780 RETURN
5790 REM
5800 REM    :----------------------------------:
5810 REM    :     Absorpbtion vrs wavelength   :
5820 REM    :        plotting subroutine       :
5830 REM    :                                  :
5840 REM    :----------------------------------:
5850 DIM Y6(40)
5860 Y6=Y8
5870 T$="ABSORPTION VRS WAVELENGTH PLOT"
5880 X$="Wavelength ([)"
5890 Y$="Absorption (1/km)"
5900 GOSUB 6030
5910 RETURN
5920 REM save extinction and absorption data on tape
5930 PRINT "WHAT FREE TAPE FILE SHALL I USE?"
5940 INPUT I
5950 FIND I
5960 PRINT "WHAT SEQUENCE NUMBER SHALL I USE?"
5970 INPUT I
5980 PRINT @33:I,C0,W0,W9
5990 PRINT @33:R9,V9,F,A9
5995 PRINT @33:A1,A2,A3
6000 PRINT @33:L,Y7,Y8
6010 CLOSE
6020 RETURN
6030 REM PLOT OF VARIABLE Y6 VRS WAVELENGTH
6040 PAGE
6050 Y9=1.0E-99
6060 Y0=1.0E+99
6070 FOR I=1 TO 40
6080 Y9=Y6(I) MAX Y9
6090 Y0=Y6(I) MIN Y0
6100 NEXT I
6110 Y9=INT(LGT(Y9))+1
6120 Y0=INT(LGT(Y0))-1
6130 VIEWPORT 20,110,10,90
6140 WINDOW -2,2,Y0,Y9
```

```
6150 AXIS @U9:1,1,-2,Y0
6160 AXIS @U9:1,1,2,Y9
6170 MOVE @U9:LGT(L(1)),LGT(Y6(1))
6180 FOR I=2 TO 40
6190 DRAW @U9:LGT(L(I)),LGT(Y6(I))
6200 NEXT I
6210 GOSUB 1500
6220 GOSUB 1670
6230 RETURN
6240 PAGE
6250 PRINT "Zonal catagory is ";C0
6260 PRINT "Airmass parameter is ";A9
6270 PRINT "Average wind speed is ";W0
6280 PRINT "Current wind speed is ";W9
6290 PRINT "Relative Humidity is ";R9
6300 PRINT "Visibility is ";V$
6310 INPUT A$
6320 RETURN
6330 U9=1
6340 GO TO 170
6350 END
```

END

DATE
FILMED

9 83

DTIC